epitaphs of the seventeenth century,' Sarah A. P. Andrews; 'Popular medicine, customs and superstitions of the Rio Grande,' Capt. John G. Bourke; 'Plantation courtship,' Frank D. Banks; 'Retrospect of the folk-lore of the Columbian Exposition,' Stewart Culin; 'Eskimo tales and songs,' Franz Boaz; 'Popular American Plant Names,' Fannie D. Bergen.

A large number of papers were read before the Society and discussed by the members present. The first was by Dr. Washington Matthews, entitled 'A Navaho Myth,' which related in detail one of the sacred legends of the tribe.

Capt. R. R. Moten then read a paper on 'Negro folk-songs,' in which he spoke of natural musical tendencies of the colored race and reviewed a number of the old songs of the South before the war. Negro music, he said, might be divided into three kinds, that rendered while working, a different kind for idle hours, and a third and more dignified sort used for worship. Capt. Moten said the general public had but little idea of the old negro music, and that many of the so-called negro songs rendered by white men in minstrel performances were abortions. There were some old familiar melodies, however, which were true to nature, and full of inspiration.

A quartet of colored men was present, and sang a number of negro songs illustrating the points brought out by Capt. Moten.

Several speakers dwelt upon the important question of the diffusion of folk-tales and the explanation of striking similarities found in localities widely apart. Mr. W. W. Newell was inclined to explain such by theories of transmission; while Major J. W. Powell and Dr. D. G. Brinton, both of whom had papers on closely related topics, leaned toward the 'anthropologic' explanation, which regards those similarities as the outgrowth of the unity of human psychological nature and methods.

Dr. J. W. Fewkes gave a detailed description of the figures in the ancient Maya manuscript known as the 'Cortesian Codex.' Other papers presented were: 'Kwapa folk-lore,' Dr. J. Owen Dorsey; 'Korean Children's games,' Stewart Culin; 'Burial and holiday customs and beliefs of the Irish peasantry,' Mrs. Fanny D. Bergen; 'Bibliography of the folk-lore of Peru,' Dr. Geo. A. Dorsey; 'Mental development as illustrated by folk-lore,' Mrs. Helen Douglass; The game of goose with examples from England, Holland, Germany and Italy,' Dr. H. Carrington Bolton; 'The Swastika,' Dr. Thomas Wilson; 'Folk-food of New Mexico,' Capt. John G. Bourke, U. S. A.; 'Opportunities of ethnological investigation on the eastern coast of Yucatan,' Marshall H. Saville; 'Two Ojibway tales,' Homer H. Kidder.

The officers elected for the ensuing year were: President, Dr. Washington Matthews; Vice Presidents, Rev. J. Owen Dorsey, Captain John G. Bourke, U. S. A.; Permanent Secretary, William Wells Newell, Cambridge, Mass.; Corresponding Secretary, J. Walter Fewkes, Boston, Mass.; Treasurer, John H. Hinton, New York, N. Y.; Curator, Stewart Culin, Philadelphia, Pa.

D. G. BRINTON.

UNIVERSITY OF PENNSYLVANIA.

SCIENTIFIC LITERATURE.

Les oscillations électriques.—H. POINCARÉ, Membre de l'Institut. Paris, George Carré, 1894.

This work contains, briefly stated, a clear mathematical discussion of the general features of the Faraday-Maxwell electromagnetic theory in Hertzian form, and of those special problems bearing upon this theory which are of particular interest to the experimentalist. The mathematical solution of these problems is compared carefully with the results obtained, principally by the experiments of Hertz and of other investiga-

tors who have extended the field of the Hertzian method of investigation. But it should be observed that the experiments of the pre-Hertzian epoch receive their full share of attention, as, for instance, the experiments of Rowland, Röntgen, and others.

The work will undoubtedly exert a very strong influence upon the future developments of the electromagnetic theory, and deserves, therefore, more than ordinary attention. This circumstance should, in the opinion of the reviewer, excuse the length of this review.

General Theory.—Poincaré's discussion divides itself naturally into two parts. In the first part an electromagnetic field with conductors at rest is considered. In the second part the discussion extends to electromagnetic fields with conductors in motion.

The Hertzian method of presentation is adopted in preference to the Maxwellian. Two distinct differences between these two methods should now be pointed out. The first difference is essential, and may be stated briefly as follows :—

Hertz described Maxwell's electromagnetic theory as the theory which is contained in Maxwell's fundamental equations ; he stated, however, very clearly that the suppression of all direct actions at a distance is a characteristic feature of this theory. But if it is not a sufficient hypothesis, and if no other hypotheses are clearly stated by Maxwell, then his deduction of the fundamental equations which form the heart and soul of his theory must necessarily lack in clearness and completeness. This is the difficulty which Hertz discovered in Maxwell's systematic development of his own electromagnetic theory, and Hertz obviates this difficulty by starting from the equations themselves as given, proving their correctness by showing that they are in accordance with all our experience.

The second difference is formal only. It may be stated briefly as follows: Maxwell considered the electrotonic state, discovered by Faraday, as of fundamental importance. The mathematical expression of this state, the vector potential, was considered by him as the fundamental function in his mathematical presentation of Faraday's view of electromagnetic phenomena. Hertz, just as Heaviside did some time before him, considered the vector potential as a rudimentary concept which should be carefully removed from the completed theory just as the scaffolding is removed from a finished building. In place of the vector potential Hertz substituted the electric and the magnetic force as the fundamental quantities. This enabled him to state the fundamental equations of Maxwell in a more symmetrical form than Maxwell did.

It seems that it is principally this second, the formal, difference which decides Poincaré in favor of the Hertzian method. But there is still considerable difference between the presentation of the electromagnetic theory given by Hertz and that which Poincaré gives in this book. For whereas Hertz proceeded from the symmetrical form of Maxwell's fundamental equations as given and by deducing from them and from several clearly defined assumptions the general experimentally established laws of electrical phenomena proved the correctness of these equations, Poincaré deduces them from the following experimentally established facts :

1. The energy of the electromagnetic field consists of two parts, one due to the action of the electric and the other to that of the magnetic forces. They are each homogeneous quadratic functions of the two fundamental quantities, that is of the electric and of the magnetic forces respectively. This experimental relation defines the units of the electric and of the magnetic force and also the physical constants of the medium, that is the specific inductive capacity and the magnetic permeability.

2. Having defined the meaning of mag-

netic and of electric induction and of their fluxes in terms of the corresponding forces, Poincaré states then the fundamental law of electromagnetic induction in a closed conducting circuit as an experimental fact and deduces immediately the first group of the Maxwellian equations. This group is nothing more nor less than a symbolical statement that the law of electromagnetic induction is true for every circuit whether it be conducting or not.

3. Joule's law is stated as an experimental fact. In a homogeneous conductor the heat generated per unit volume and unit time at any point of the conductor is proportional to the square of the electric force at that point; the factor of proportionality is electrical conductivity by definition. Another quantity is then introduced which is defined as the product of the electrical force into the conductivity and the name of conduction current is given to it.

By means of these definitions, the principle of conservation of energy, and the first group of Maxwellian equations, the second group, in the form given by Hertz, is then deduced. This completes the Maxwellian electromagnetic theory for a homogeneous isotropic field in which both the medium and the conductors are at rest.

Poincaré loses no time in commenting upon the physical meaning of these equations, but proceeds rapidly to Poynting's theorem, which introduces one of the most important quantities in the wave-propagation of electromagnetic energy. It is the radiation vector, as Poincaré calls it. A brief remark, however, prepares the reader for the good things that are to come. A comparison of Maxwell's fundamental equations with those of Ampère shows them to be identical except for rapid electric oscillations, when the displacement currents (Poincaré does not mention this name, but only refers to a mathematical symbol) in the dielectric cease to be negligibly small. For these no provision was made in Ampère's or any other of the older theories. Here then is the starting point of the radical departure of the Faraday-Maxwell view from that of the older theories. Hence the study of Hertzian oscillations takes us into a new region of electrical phenomena, a region entirely unexplored by the older theories, and first brought before our view by the discoveries and surmises of Faraday, by Maxwell's mathematical interpretation of these discoveries and surmises, and by Hertz's confirmation of Faraday and Maxwell.

Hertzian Oscillations.—It is the study of these rapid oscillations which forms the subject of the rest of Poincaré's work under consideration.

Sir William Thomson's theory of the discharge of a Leyden jar forms a fitting introduction to this study. It states clearly the essential elements which should be considered in the study of electric oscillations. They are the period and the decrement. The relation of these to the self-induction, the electrostatic capacity, and the resistance of the circuit are given by this theory and it was verified by many experiments, especially those of Feddersen, who measured the period of these oscillations and also their decrement by a photographic method. But inasmuch as these oscillations were of a comparatively long period, 10^4 per second, they were not apt to furnish a test of the Faraday-Maxwell theory. The waves of the oscillations studied by Feddersen would have been 30 kilometers long and would, therefore, have escaped experimental detection.

Hertz was the first to produce very rapid oscillations, 10^8 per second; but since their period was too short to be measured directly, another method of testing the agreement between theory and experiment had to be devised. This was done by Hertz,

who measured the wave length (about 3 metres in the earliest experiments) of the waves produced by these rapid oscillations by means of the intensity of the spark in the spark-gap of a secondary circuit, the so-called resonator. The period was calculated by the Thomson formula and dividing the wave-length by the period gave the velocity of propagation, which, according to the Faraday-Maxwell theory, should be equal to that of light, and that, too, both in the immediate vicinity of the conductors and in the dielectric. A mere sketch of these experiments is given for the purpose of outlining the plan of the discussion to be carried out in the succeeding chapters of the book. Hertz's method of calculating the period of his oscillators is reproduced more or less faithfully and the various objections against it discussed.

Theory of Hertzian Oscillations.—This discussion paves the way gradually for the general theory of the Hertzian oscillator to be taken up in the next chapter. This theory can be described as the mathematical discussion of the following problem: Given a homogeneous dielectric extending indefinitely. This dielectric is acted upon by a steady electrical force applied at a conducductor, the oscillator. It is therefore electrically strained. Describe the process by means of which the dielectric returns to its neutral state when the initial electrical strain is suddenly released.

The discussion must necessarily start from Maxwell's fundamental equations. They are in the form given by Hertz, partial differential equations connecting the components of the electric and of the magnetic forces at any point in the dielectric. Hence, using the language of the mathematician, the solution of the above problem will consist in the integration of Maxwell's differential equations, which, translated into the language of the experimental physicist, means that the solution will consist in finding the resulting electrical wave, that is, its period, its decrement due to radiation and dissipation, and its direction and velocity of propagation. It is evident, therefore, both to the mathematician and to the physicist that the conditions at the boundary surfaces separating the dielectric from the conductor must first be settled. To these Poincaré devotes careful attention. A lucid demonstration is given of the theorems that in the case of rapid oscillations there will be: a. Very slight penetration of the current into the conductor; b. A vanishing of the electric and the magnetic force in the interior of the conductor. c. Electric force normal and magnetic force tangential to the surface of the conductor, etc.

Then follows a beautiful mathematical solution of the general problem mentioned above. It is this: The law of distribution of the conduction current on the oscillator being given the electric and magnetic force, and therefore the state of the wave, at any point in the dielectric and at any moment can be calculated by a simple differentiation of a quantity called the vector potential. This quantity is determined from the current distribution in a manner which is the same as that employed in the calculation of the electrostatic potential from the distribution of the electrical charge, but on the supposition that the force between the various points of the dielectric and the surface of the oscillator is propagated with the velocity of light. The value of this solution rests on the fact that the law of distribution of the conduction current can be closely estimated in some oscillators, as, for instance, in the case of Blondlot's oscillator consisting of a wire bent so as to form a rectangle in one of whose sides a small plate condenser is interposed. A special form of this vector potential applicable to oscillators whose surface is that of revolution is deduced and applied to Lodge's spherical oscillator,

whose oscillations are due to a sudden release of a uniform electrostatic field. The solution of this case is complete. The actual values of both the period and the decrement are expressed in terms of the radius of the sphere. The smallness of the period and the exceedingly rapid rate of decay of the wave are striking.

This theory throws much light upon Hertz's method of calculating the period of an oscillator. Poincaré applies it also to the explanation of the Hertzian method of calculating the decrement due to electrical radiation and the force of Poynting's theorem is exhibited in a masterly manner, although, of course, the calculation for more general cases is not as complete as that for Lodge's oscillator. More experimental guidance is necessary and will not be sought in vain in subsequent chapters.

Phenomena of Electrical Resonance.—Wave Propagation along a Wire.—Having described Hertz's method of calculating the period and the decrement, Poincarè discusses next some of the more important experimental researches dealing with these two principal characteristics of an oscillating system. The earliest method employed in researches of this class is that devised by Hertz. A secondary circuit, the resonator, consisting of a turn of wire with an adjustable spark gap is brought into the inductive action of the oscillator. The length and intensity of the induced spark measures the inductive effect between the two. When the periods of the two are equal the effect is a maximum; they are then in resonance. But experiment reveals the fact that the resonance effect is not as pronounced as in the case of acoustical resonance. Sarasin and de la Rive (Arch. des sciences phys. 23, p. 113; 23, p. 557, Génève, 1890) inferred from this that the oscillator sends forth a complex wave which, if analyzed in the manner of a ray of sunlight, would give a continuous spectrum. Poincarè, guided by a carefully worked general theory of resonance, ascribes the absence of a strong resonance effect to the large decrement of the oscillator. An appeal is then made to experiments bearing on this point and the subject of stationary waves in long wires is taken up. Such waves are produced in the same way as in the case of sound waves. When a train of electrical waves travels along a wire and the leading wave reaches the end of the wire it is reflected there and by the interference between the direct and the reflected waves stationary waves are formed. Hertz's theory of propagation of these waves is given, showing that their velocity is the same all along the wire and equal to that of light for all wave lengths. If the view of Sarasin and de la Rive be correct then stationary electrical waves should have no pronounced nodes and ventral segments and, therefore, a resonator which, unlike the oscillator, gives a simple wave of definite periodicity will pick out of the stationary waves that component only which is in resonance with it. In other words, every resonator, within large limits, will respond to stationary waves and if moved along a wire which is the seat of such waves its spark will rise and fall in intensity every time the resonator passes by a node or a ventral segment of that component contained in the complex stationary wave with which it is in resonance. It measures, therefore, the wave length corresponding to its own period and not that corresponding to the period of the oscillator. This wave length divided by the calculated period of the vibrator will give, therefore, a wrong velocity of propagation. A mistake of this kind was suspected in Hertz's earliest experiments by which he obtained a different velocity of propagation along a wire from that in the dielectric. Sarazin and de la Rive called this phenomenon, first observed by them, the phenomenon of multiple resonance. It is undoubtedly one of the most

important discoveries in the region of Hertzian oscillations. It was probably [1] Poincaré (his modesty prevents him from mentioning this fact) who first recognized its full value and detected its true meaning. He devotes a large part of the present work to the discussion of this phenomenon and every serious student will appreciate heartily this very interesting feature of the noble work before us. Briefly stated Poincarè's explanation of multiple resonance is this. Ordinarily the oscillator has a large decrement; that of the resonator is very small, according to the results of Bjerkness' experiments. The train of waves excited in a long wire by the inductive action of an oscillator after each disruptive discharge consists of a big wave followed by a small number of waves of very rapidly decreasing amplitude. Such a train of waves is evidently not capable of forming interference waves after reflection. Their effect upon the resonator is practically the same as that of a single wave, giving the resonator an impulse when passing it on its way toward the end of the long wire and another impulse when it returns after reflection. Hence, if the time interval between these two impulses is a multiple of the period of the resonator the resulting oscillation in the resonator will be stronger than otherwise. If, therefore, the resonator be moved along the long wire its oscillations will vary, passing through a maximum at regular intervals; the distance between these intervals being equal to a wave length corresponding to the period of the resonator. But, obviously, the maxima will be most clearly pronounced when the resonator is in resonance with the oscillator. This is especially true in the case of oscillators possessing a less strongly developed decrement, as for instance, Blondlot's oscillator. This explanation is illustrated by a mathematical discussion of rare elegance and simplicity. Blondlot's experiments (Jour. de Phys. 2 serie t. X., p. 549) are then carefully described and the close agreement between them, especially as regards the velocity of propagation along conducting wires, and the above theory pointed out.

Attenuation of Waves.—An important feature connected with wave propagation of Hertzian oscillations along wires was strongly emphasized by these experiments, namely, the diminution of the wave amplitude with the distance passed over. This has long since given Mr. Oliver Heaviside many an anxious thought. Poincaré is evidently not aware of that and he attacks the problem with just as much of his well-known mathematical vigour as if its solution had not been given long ago by Mr. Heaviside. (Electr. Papers, Vol. II., p. 39, etc.) A few bold strokes of Poincaré's unerring pen disclose the interesting fact that the attenuation is due, principally, to distributed capacity of the wire, since the decrement, calculated by Poynting's theorem, is shown to be inversely proportional to the diameter of the wire. Experimental evidence bearing upon this point is then reviewed. In these experiments the employment of the resonator had to be discarded and the intensity of the wave at various points of the wire measured directly. Various methods were employed in these experiments. The most important among them are the following:—

a. Hertz's method (Wied. Ann. 42, p. 407, 1891) of measuring the intensity of the wave at any point of a long wire by the mechanical force exerted upon another small conductor suspended in the vicinity of the wire. This method permits a study of the

(1) It is no more than just that a strong emphasis should be put upon the fact that Bjerkness independently (Wied. Ann. 44 p. 74 and p. 92, July, 1891) worked out the same theory and proved it by experiment at about the same time that Poincaré first published his theory (Arch. des sciences phys. 25 p. 608, Génève 15 Juin, 1891).

distribution of the magnetic and the electric force along the wire separately.

b. The method of Bjerkness (Wied. Ann. 44, p. 74) in which two symmetrically situated points of a long loop are connected to the quadrants of a small electrometer and the difference of potential measured.

c. The thermoelectric method [first suggested by Klemencic (Wied. Ann. 42, p. 416)] employed by D. E. Jones (Rep. Brit. Assoc., 1891, p. 561–562). The intensity of the wave at any point of the wire is measured by the thermoelectric effect produced in a thermopile placed in the immediate vicinity of that point.

d. The bolometric method first employed by Rubens and Ritter (Wied. Ann. 40, p. 55, 1890).

e. Perot's micrometric spark gap method (C. R. t. CXIV., p. 165) by which the intensity of the wave at any point is measured by the maximum length of the spark gap when attached to the wire at that point.

The theory of each method is discussed briefly but quite completely, and it is shown very clearly that the results of the experimental investigations cited above are in good agreement with the theory and that they all lead to the conclusion that the oscillations of the oscillator produce simple waves, possessing a rapid rate of decay. This is in accordance with Poincaré's view of multiple resonance.

Bjerkness' experimental method (Wied. Ann. 40, p. 94, 1891) of determining the decrement of a resonator and Poincaré's theory of it are then given and it is shown that this decrement is a hundred times smaller than that of the oscillator.

A brief theoretical discussion of the curves plotted by Perot from the experiments cited above closes this exceedingly interesting and instructive part of the book.

It is pointed out now that the experiments so far discussed do not decide the superiority of the Maxwellian theory over the older theories because it can be and has been predicted by older theories (Kirchhoff, Abhandl. p. 146) that the velocity of propagation of electromagnetic disturbances along a long straight wire suspended in air is the same as the velocity of light. A review of some of the older experiments in this direction is then given.

Direct Determination of the Velocity of Propagation along Conducting Wires.—The earliest experiments carried out according to methods against which no serious objections could be raised were those of Fizeau and Gounelle (1850) over telegraph lines between Paris and Amiens, a distance of 314 kilometers. The method was similar to that employed by Fizeau in the determination of the velocity of light. The mean velocity was found to be 10^5 kilometers per second for iron wire and 18×10^4 kilometers per second for copper wire. They employed signals of, comparatively speaking, long duration, and Poincaré shows by a reference to well known theoretical relations that in this case there is a strong distortion of the signals, so that a disturbance starting in form of a short wave returns, after passing over the whole line, in form of a more or less steep wave front followed by a long tail. This made the measurements very uncertain and the velocity of propagation necessarily much smaller than it ought to have been. The experiments of Siemens in 1875 avoided this objection, in a measure, by employing the disruptive discharge of a Leyden jar for the purpose of starting an electrical disturbance on lines of varying length, between about 7 and 25 kilometers. The velocity found was in several cases nearly 250,000 kilometers for iron wire. Here again the velocity came out smaller than that of light and for obvious reasons.

The last and in all respects most successful direct determination of the velocity of propagation was that recently carried out by

Blondlot (C. R., 117, p. 543; 1893). The signals were sent over a wire of about one kilometer in length and another of about 1.8 kilometers. In the first case the mean velocity was found equal to 293,000 and in the second to 298,000 kilometers per second which is very close to the velocity of light. Poincaré proceeds now to the discussion of the most severe test of the Maxwellian theory, that is the propagation of electromagnetic waves through dielectrics.

M. I. PUPIN.

COLUMBIA COLLEGE.

(*To be Concluded.*)

Model Engine Construction.—J. ALEXANDER.—New York and London, Whitaker & Co. 1894. Illustrated by 21 sheets of drawings and 59 engravings in the text. 12mo, pp. viii + 324. Price, $3.00.

This little book is an excellent treatise on the construction of models of stationary locomotive and marine engines, and contains also instructions for building one form of hot-air engine. It is written by an author evidently familiar with his subject, and the text and illustrations are such as will serve the purpose of both artificer and amateur, desiring to produce model representations of real working engines of standard forms. Bright young mechanics will find here business-like statements of details of drawing, pattern-making, and finishing such models; and, if heedfully complied with, these instructions will result in the production of steam-engines which will actually 'steam,' and which will delight the heart of the mechanician. The drawings are all representative of British practice, and, in some respects, therefore, quite different from familiar practice in the United States; but British practice is 'not so bad,' after all, and many old mechanics, and probably every amateur, will be able to profit greatly by the careful study of this little work.

R. H. T.

NOTES.

PERSONAL.

KARL HANSHOFER, Professor in the University of Munich, and well known through his researches in crystallography and other branches of mineralogy, has died at Munich at the age of fifty-four.

PROF. G. LEWITZKY has been appointed Director of the Observatory in Dorpat, and Dr. L. Sturve succeeds Professor Lewitzky at Charkow.

PROF. F. KOHLRAUSCH, of Strassburg, was proposed as the successor of Hertz at Berlin, but the death of Helmholtz intervening he will now succeed the latter in the Directorship of the Physico-Technical Institute.

GENERAL.

THE discontinuation of the *Index Medicus* is threatened unless sufficient subscriptions are secured before February 1 to defray the costs of publication.

ACCORDING to the *Publishers' Circular* there were 5,300 new books and 1,185 new editions published in Great Britain during 1895, 203 more than during 1894. Of these, 98 new books and 30 new editions are placed under the heading 'Arts, Sciences and Illustrated Works.'

MR. GEORGE F. KUNZ, Special Agent, Division of Mining Statistics and Technology, U. S. Geological Survey, has sent letters asking for imformation concerning the freshwater pearl fisheries, and concerning precious and ornamental stones of the United States.

PROF. S. P. LANGLEY, Secretary of the Smithsonian Institution, has addressed a letter to the competitors for the Hodgkins Fund Prizes of $10,000, of $2,000, and of $1,000, stating that in view of the very large number of competitors, of the delay which will be necessarily caused by the intended careful examination, and of the futher time which may be required to con-